P-52

Piezoelectric properties of the crystals of *ortho*-carboranyl (*S*)-phenylalanine and (*S*)-valine derivatives

D.A. Gruzdev[1], A.S. Nuraeva[2], V.O. Ustinova[1,2], P.A. Slepukhin[1,3], P.S. Zelenovskiy[2], V.P. Krasnov[1], V.Ya. Shur[2]

[1]*Postovsky Institute of Organic Synthesis of the Russian Academy of Sciences (Ural Branch), 620990, Ekaterinburg, Russia.*
gruzdev-da@ios.uran.ru

[2]*School of Natural Sciences and Mathematics, Ural Federal University, 620000, Ekaterinburg, Russia*

[3]*Institute of Chemical Engineering, Ural Federal University, 620000, Ekaterinburg, Russia*

Piezoelectric response of the crystals of carborane-containing *pseudo*-dipeptides was measured using the piezoresponse force microscopy. Observable piezocoefficients of the crystals reached 76.2 pC/N. Structure and stereo configuration of compounds affected the piezoelectric response of the crystals.

The development of novel piezoelectric and ferroelectric organic materials is an important trend of modern chemical physics [1, 2]. Organic piezoelectrics are flexible, biocompatible and environmental friendly. Recently we used the piezoresponse force microscopy to study the piezoelectric properties of diphenylalanine nanotubes [3] and crystals of some carborane-containing amino acid derivatives [4, 5].

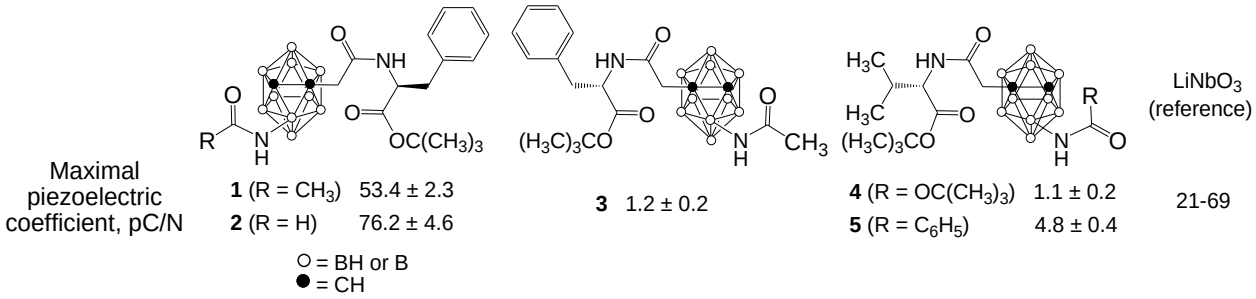

Figure 1. Structure of carborane derivatives and maximal observable piezoelectric coefficients.

In this work, single crystals of protected *pseudo*-dipeptides **1-5** bearing the carborane moiety and the residues of natural amino acids, (*S*)-phenylalanine and (*S*)-valine were obtained. Morphological study and X-ray diffraction analysis of crystals **1-5** were performed. The crystals belong to chiral space groups which allow non-zero piezoelectric tensors. Piezoelectric response of the crystals was measured using the piezoresponse force microscopy in vertical and lateral dimensions at various cantilever-crystal relative orientations in the plane.

It has been established that the crystals of compounds **1** and **2** possess strong piezoelectric activity (comparable with that of $LiNbO_3$). Piezoelectric response of the crystals of compounds **3-5** was significantly lower. It has been demonstrated that piezoelectric properties depend on the stereo configuration of the chiral plane in carborane fragment (compounds **1** and **3**).

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